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DECEMBER 1960

**TECHNICAL
REPORT**

**EVALUATION OF TELETYPE MULTIPLEX EQUIPMENT
AN/TCC-35**

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EVALUATION OF
TELETYPE MULTIPLEX EQUIPMENT
AN/TCC-35

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Project No.: 4538
Task No.: 55129

Rome Air Development Center
Air Research and Development Command
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Griffiss Air Force Base, New York

A B S T R A C T

This report describes a complete evaluation test program conducted by the USAF on the AN/TCC-35 Teletype Multiplex Equipment, and presents the conclusions and recommendations of test personnel. Eight service test models of the AN/TCC-35 Teletype Multiplex Equipments were delivered to the USAF by Rixon Electronics, Inc. for operational Forward Propagation Ionospheric Scatter (FPIS) circuits between Wachusett, Massachusetts and Thule, Greenland. Two units were subjected to rigorous evaluation tests by RADC at Rome, New York.

The test results indicated that, in general, AN/TCC-35 Teletype Multiplex Equipments are capable of reliable performance over FPIS circuits. However, before this equipment can be successfully integrated into present USAF teletype circuits certain modifications based on the test results will have to be incorporated to increase reliability and compatibility with existing equipment. It is recommended that the AN/FGC-54 Teletype Multiplex Equipment which is based on the AN/TCC-35 design philosophy be used to meet USAF requirements.

P U B L I C A T I O N R E V I E W

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TABLE OF CONTENTS

<i>Contents</i>	<i>Page</i>
INTRODUCTION	1
BACKGROUND	1
DESCRIPTION	3
BASIC OPERATING THEORY	4
MULTIFLEXING OF TELETYPEWRITER INFORMATION	10
AUTOMATIC FREQUENCY CONTROL	13
GENERAL OBJECTIVES OF OVERALL TEST PROGRAM	14
RADC EVALUATION TESTING	15
BACKGROUND	15
ENDURANCE TESTS	15
RUGGEDNESS TESTS	16
ENVIRONMENTAL TESTS	17
EVALUATION TEST RESULTS AND CONCLUSIONS	18
AFOTC OPERATIONAL TESTING	19
TEST OBJECTIVES AND REQUIREMENTS	19
DESCRIPTION OF TESTS AND TEST EQUIPMENT	20
MAINTAINABILITY	23
OPERATIONAL TEST RESULTS AND CONCLUSIONS	24
RESULTS	24
CONCLUSIONS	27
RECOMMENDATIONS	28
SUMMARY	30

LIST OF ILLUSTRATIONS

<i>Figure</i>		<i>Page</i>
1.	AN/TCC-35 Teletype Multiplex Equipment	2
2.	Transmitter Monitor Unit	4
3.	Receiver Monitor Unit	5
4.	Simplified Block Diagram of Multiplex System	6
5.	Transmitter Block Diagram	8
6.	Receiver Block Diagram	9
7.	Multiplex Timing Chart	11

December 1960

EVALUATION OF
TELETYPE MULTIPLEX EQUIPMENT
AN/TCC-35

INTRODUCTION

BACKGROUND

The AN/TCC-35 Teletype Multiplex Equipment described in this report was developed for use in the Northeast Air Command Forward Propagation Ionospheric Scatter (FPIS) Radio Circuits. Figure 1 is a picture of the equipment.

Functional and environmental testing of the equipment was performed at RADC and the operational feasibility of the equipment was determined by RADC evaluation of the test data obtained by AACS use of the AN/TCC-35 on NEAC FPIS Circuits. Rixon Electronics, Incorporated, developed an experimental model of the equipment beginning in 1955 for the Massachusetts Institute of Technology, Lincoln Laboratories. Preliminary research included a detailed study of transistors and magnetic storage circuits to determine the adaptability of such circuits to the equipment function. Such problems as phase synchronization, frame synchronization, and the use of transistors for magnetic shift registers were resolved. Additional features were incorporated during design of the system, such as printed circuits, plug-in module units, and interchangeability of sub-units. Eight prototype units were constructed for AFCRC and RADC and the first system was delivered to RADC in 1957.

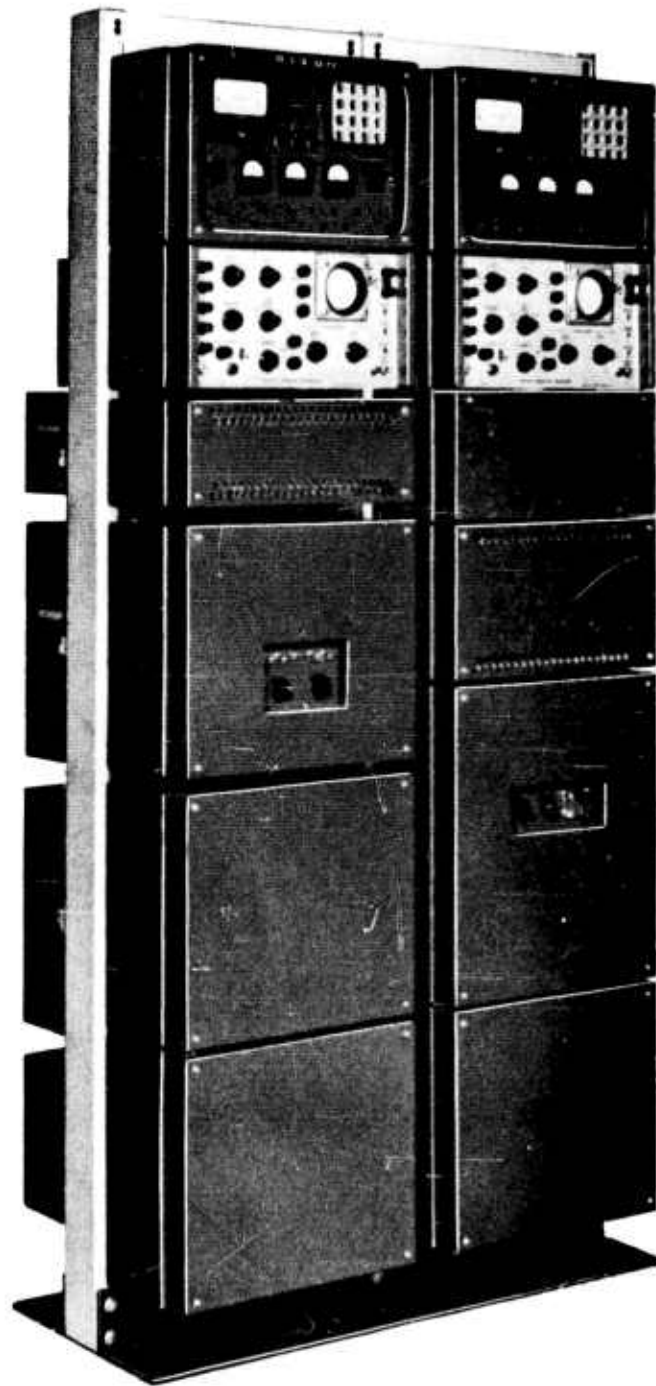


FIGURE 1. AN/TCC-35 TELETYPE MULTIPLEX EQUIPMENT

DESCRIPTION

The equipment accomplishes time-division multiplexing of 2, 4, 8 or 16 teletypewriter (TTY) channels. The multiplex (MUX) equipment handles standard 7.42 unit TTY code at 60, 75 or 100 words per minute. The equipment consists of a group of transmitter units that convert a TTY signal into multiplex form and of a group of receiver units that reconvert a multiplexed TTY signal to standard TTY form. There are sixteen identical Transmitter Code Converters which change a TTY input into a form that can be multiplexed. A Transmitter Control Unit consisting of a MUX Generator (MUX GEN) performs the multiplexing operation, and a Timing Generator supplies timing pulses to the Transmitter Code Converters. A Receiver Control Unit de-multiplexes the composite signal, and a Receiver Timing Generator supplies timing pulses to the Receiver Code Converters. Sixteen identical Receiver Code Converters regenerate the TTY characters onto sixteen different channels. An Automatic Frequency Control (AFC) in the receiver slaves the Receiver Master Oscillator (MO) to the Transmitter Master Oscillator (MO).

The transmitter and the receiver each require a standard 19-inch relay rack 84 inches high. All chassis are housed in articulated hinged modules that allow access to both sides of each chassis without its removal or disconnection from the equipment. All disconnect fittings are Amphenol Blue Ribbon type and have wide contact surfaces.

Each unit is equipped with a Monitor Unit, Figures 2 and 3, and Test Oscilloscope connected directly to the operational circuitry.



FIGURE 2. TRANSMITTER MONITOR UNIT

Semi-conductor power supplies are mounted on the bottom of each rack. A built-in test unit permits checking of modules when they are removed from their plug-in position.

EASIC OPERATING THEORY

Figure 4 shows a simplified Multiplex Transmitter (MUX TRANS) and Multiplex Receiver (MUX REC) connected by a radio link. A single channel carries the necessary multiplex intelligence as well as all synchronizing information in binary form. The MUX equipment receives input intelligence at TTY speed already in binary form on each of its sixteen channels, and must sample the input signals with respect to time so that the message content of all sixteen inputs may be

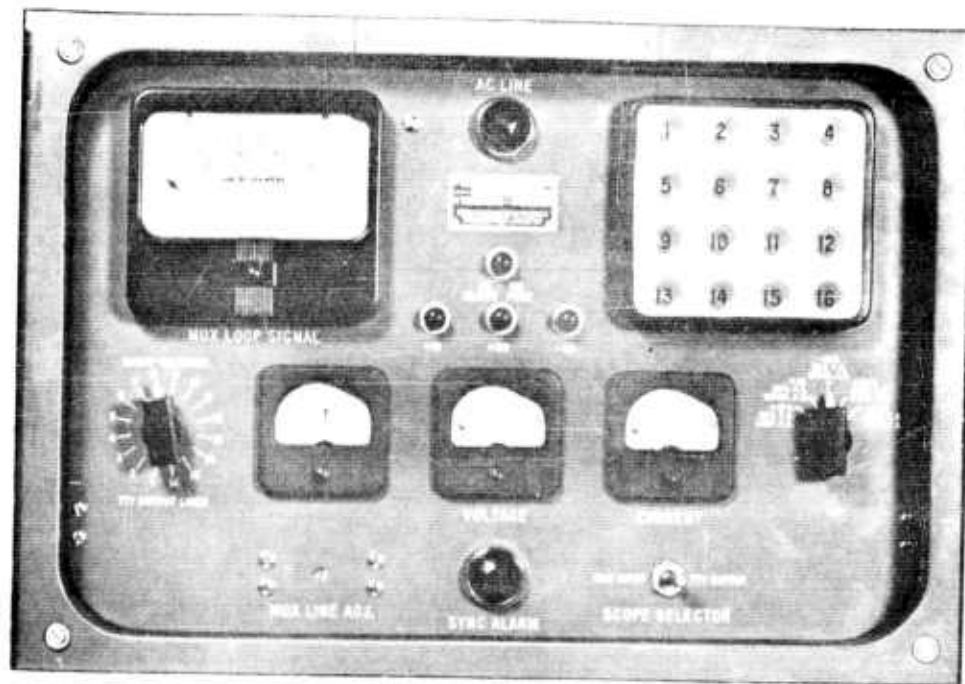


FIGURE 3. RECEIVER MONITOR UNIT

sequentially passed over a single circuit. The binary digits (bits) must be shortened in time and rearranged in serial form to generate the multiplexed signal. The bits are transmitted at a rate of approximately 16 times the bit rate of a single TTY input channel.

The input signals are supplied to the MUX in groups of binary elements with each group representing one TTY character. There are several methods of constructing the multiplex output when utilizing input signals of this type. Two methods are: first, the bit sequential system in which a single binary element is transmitted from the first channel, followed by a single element from the second channel, and so on; second, the group sequential arrangement in which an entire group representing

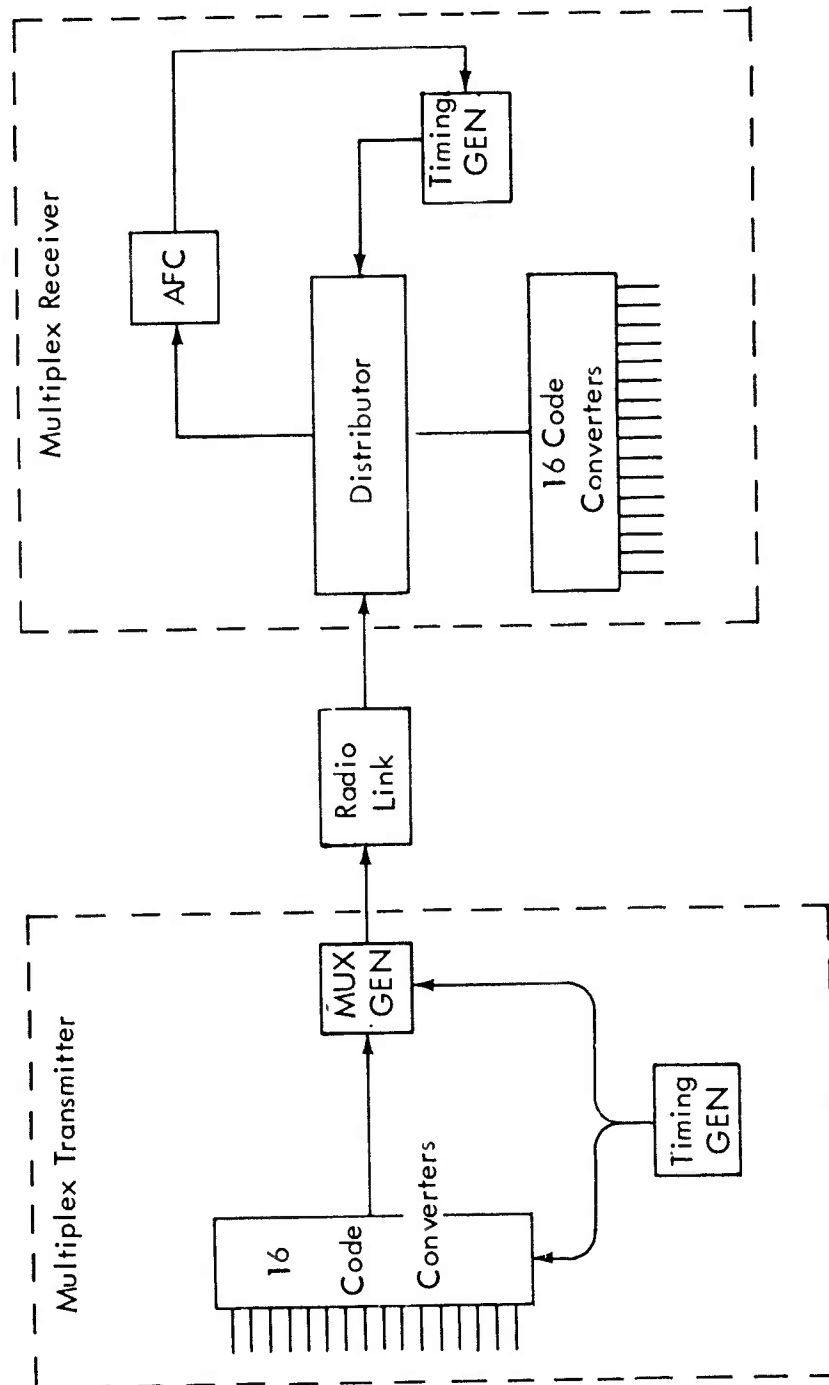


FIGURE 4. SIMPLIFIED BLOCK DIAGRAM OF MULTIPLEX SYSTEM

one teletype character is processed from each channel before going to the next. The group sequential system was adopted due to less susceptibility to short noise bursts in the radio link, as well as a greater ease of understanding by field maintenance personnel. The two systems are approximately equivalent insofar as component requirements are concerned.

As shown in Figure 5, the MUX TRANS consists of a Transmitter Timing Generator, a MUX GEN, sixteen identical Transmitter Code Converters, and a Distributor. The Code Converters store TTY signals until the MUX GEN is ready to transmit the intelligence thus stored. The MUX GEN accepts the stored intelligence from the Code Converters in sequence and delivers it at a constant bit rate to the radio equipment. The Transmitter Timing Generator accurately establishes the bit rate and provides the timing impulses required by the MUX TRANS circuits. The Distributor determines when each Code Converter will supply the stored characters to the MUX GEN.

Figure 6 is a block diagram of the MUX REC. It consists of four units: a Distributor, which accepts the MUX input signal and delivers the proper code groups to each of the sixteen Code Converters; Code Converters, which reinsert elements of the signal removed by the transmitter and produce outputs suitable for use by TTY equipment; an AFC circuit, which maintains the Receiver Timing Generator at the same frequency and at the correct phase in relation to the transmitter; and a Receiver Timing Generator, which serves the same general purpose in the

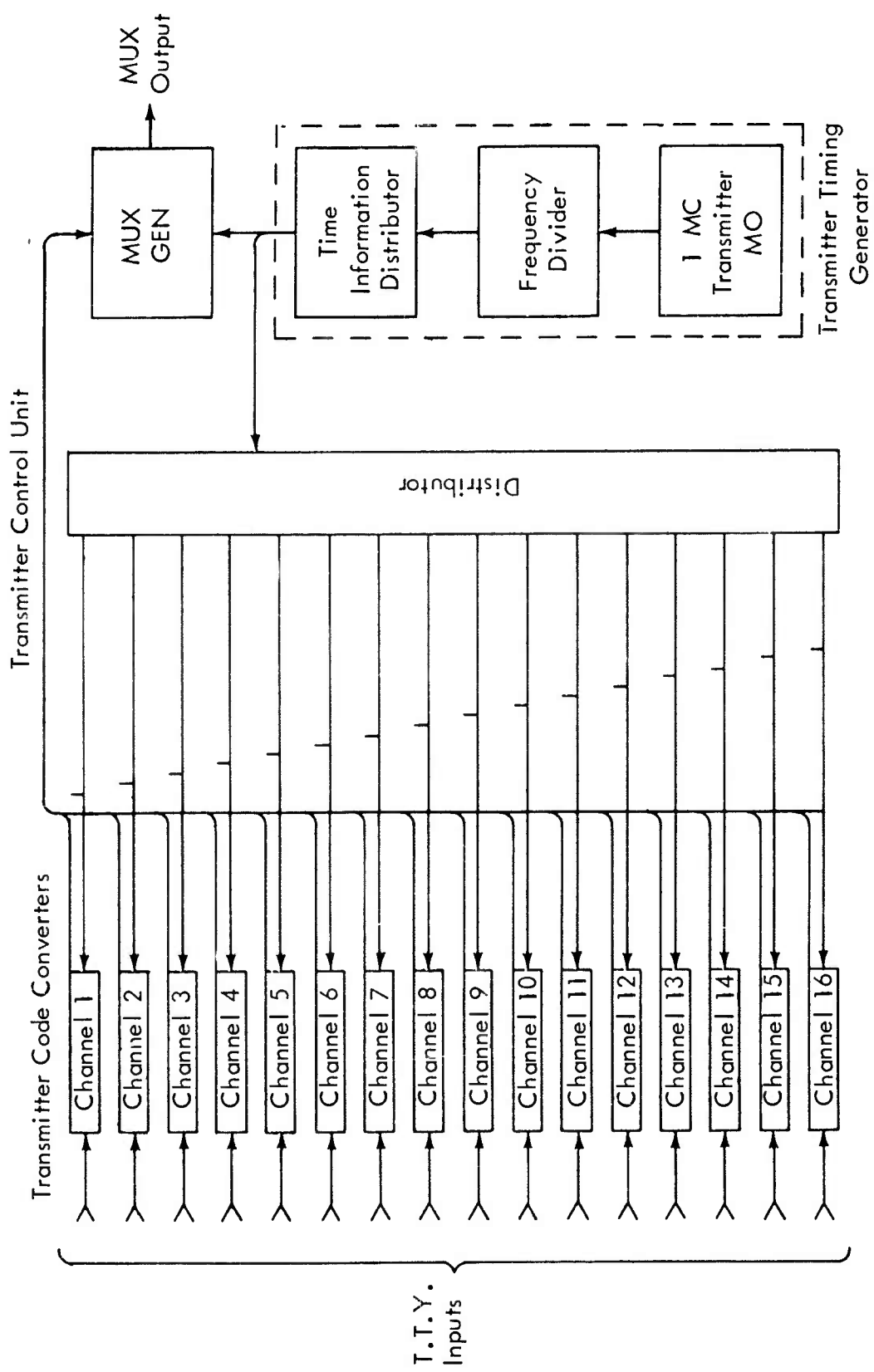


FIGURE 5. TRANSMITTER BLOCK DIAGRAM

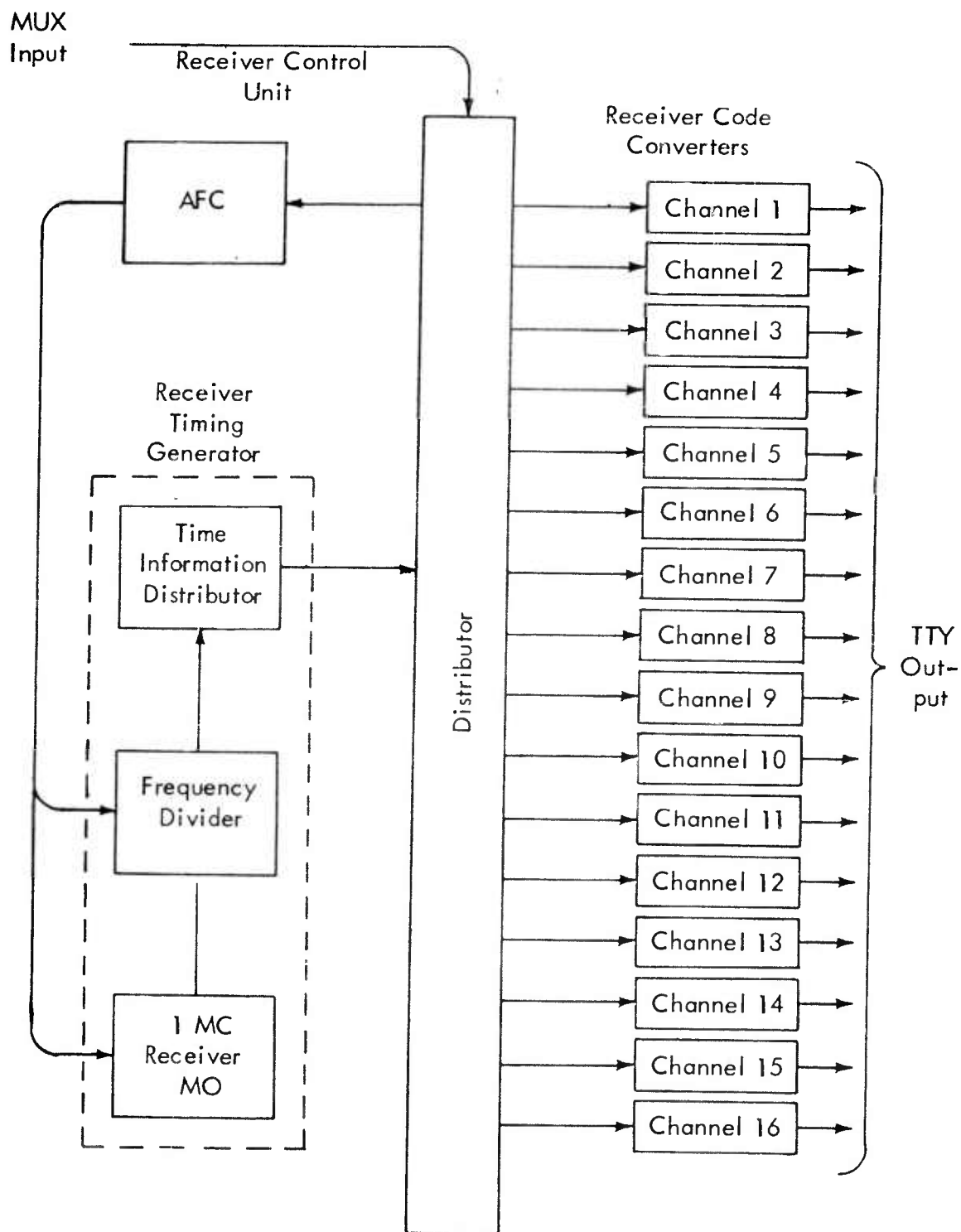


FIGURE 6. RECEIVER BLOCK DIAGRAM

receiver as does the Transmitter Timing Generator in the transmitter. The output signal from the Code Converters contains the same intelligence originally supplied to the transmitter. Although sixteen channels are shown on the block diagram, the equipment may readily be switched by a front panel control to 8, 4, or 2 channels with proportionately longer bit durations and lower bandwidth requirements.

MULTIPLYING OF TELETYPEWRITER INFORMATION. Line 1 of Figure 7 represents a standard TTY character, using the standard 7.42 unit TTY code, with a duration of 163 milliseconds at 60 words per minute. Successive start and stop elements will always have the same polarity. The five elements containing the intelligence identifying the TTY character may each have either polarity. It is necessary to transmit only these five elements since the others may be reinserted by the receiver. Line 2 shows these five elements of a TTY character; the start and stop elements have been removed.

Since the sixteen TTY channels feeding the single multiplex system are not in synchronization with one another, and all characters originated by all machines must be transmitted by the multiplex system, it is necessary that the MUX transmission be slightly faster than the fastest anticipated TTY input. With a slightly faster transmission speed, the MUX will occasionally get ahead of a given TTY channel and must therefore originate a blank transmission group, or speed differential pause. It is also necessary that the receiver be able to recognize these blanks. Since all possible five-element combinations are used by the

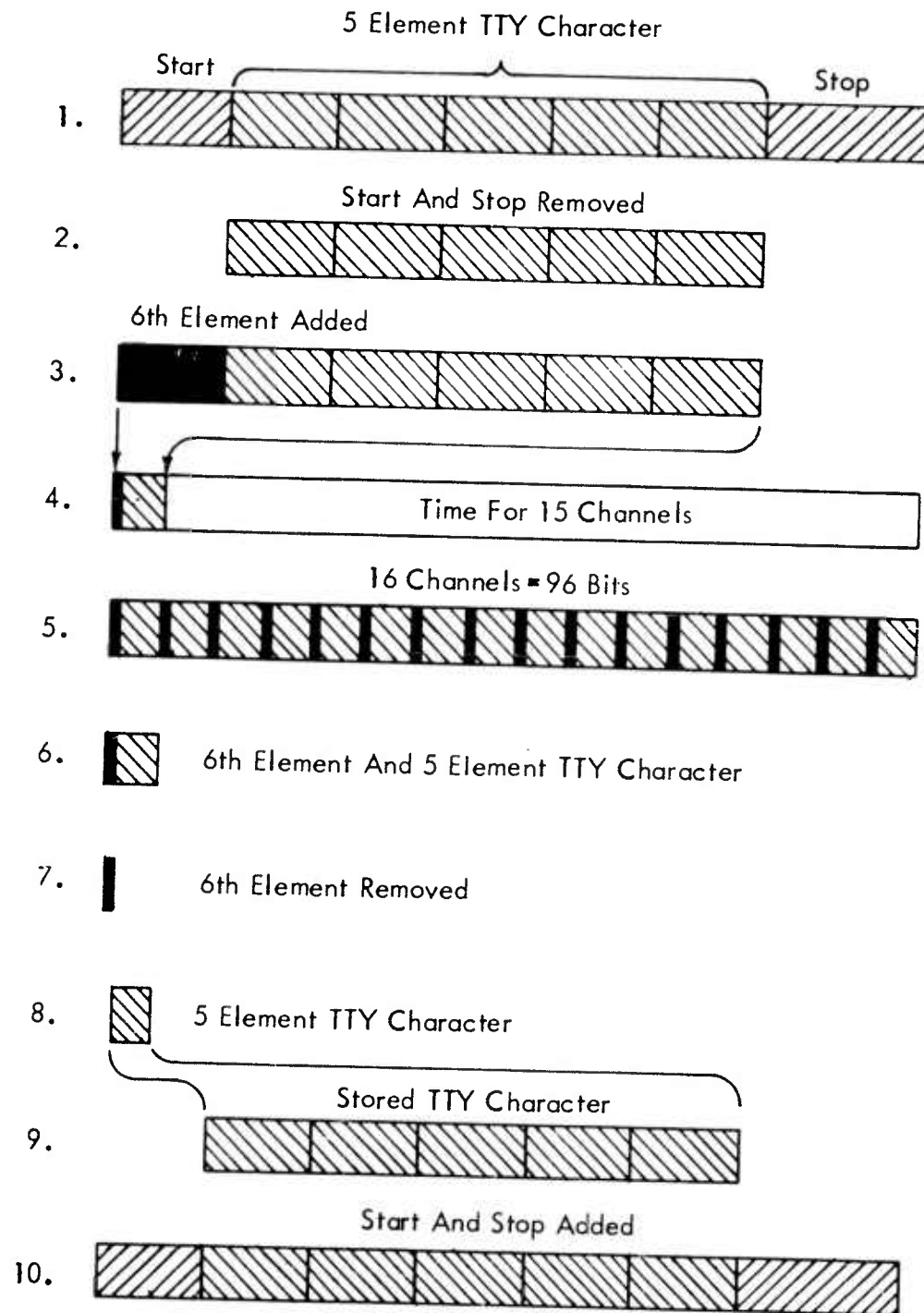


FIGURE 7. MULTIPLEX TIMING CHART

TTY system, it becomes necessary to add a sixth element ("tag bit") to distinguish the speed differential pauses from the TTY characters. This sixth element, which is shown on line 3, has two polarities; one indicates a character originated by the TTY, the other a speed differential pause.

These six elements are transmitted by the MUX in approximately one-sixteenth of the time required for their generation in a TTY system. Line 4 shows this relationship. The shaded portion of line 4 contains all the information on line 3; however, it occupies only one-sixteenth of the time, thereby providing time for the other fifteen channels. Line 5 shows the multiplex transmission made up of the six elements from each of the sixteen channels -- a total of 96 binary elements transmitted in approximately the same time as the original TTY character. Each narrow mark on line 5 represents the sixth bit of a given channel, while each of the wide marks indicates the additional five bits required to complete the transmission for each channel. Thus there is a total of 96 bits for one frame, or "operation", at the multiplex rate.

When this signal arrives at the receiver, the six-element groups are separated and distributed to the proper Code Converters. One group of six elements is shown on line 6. The Code Converter notes the polarity of the sixth element and removes it from the other five, as shown on line 7. The remaining five are stored as shown on line 8, and at the proper time these five stored elements are read out of storage

at TTY speed (line 9); the start and stop elements are added (line 10), and the original TTY character is reconstructed.

AUTOMATIC FREQUENCY CONTROL. There are two types of synchronization used in the MUX: Frame (or operation) synchronization, and MO synchronization. Frame synchronization is accomplished automatically by the Receiver Distributor; MO synchronization is performed by the AFC circuit.

The AFC circuit in the receiver monitors the incoming MUX signal and slaves the Receiver MO frequency to the Transmitter MO. The MUX REC detects the frequency of the Transmitter MO by sensing the reversals in the MUX signals and comparing the average reversal time with the corresponding timing pulses used in the receiver. Since the reversals in the MUX signal are controlled by the frequency of the Transmitter MO, and the corresponding timing pulses in the receiver by the Receiver MO, comparing the MUX reversals with these receiver timing pulses will provide the information which will enable the AFC circuit in the receiver to mechanically adjust the frequency of the Receiver MO to exact coincidence with that of the Transmitter MO. This frequency correction is accomplished by a continuous phase shifting device that changes the phase of the receiver oscillator output and at the same time makes a minute correction in the oscillator frequency to reduce the necessity for phase correction. Since the master oscillators used in the two Timing Generators shown on the block diagram of Figure 4 have a stability of better than one part in ten to the eighth power per

day, once exact synchronization has been accomplished, the system can theoretically hold the two MUX units in synchronization even though the radio link is disrupted for over 24 hours.

GENERAL OBJECTIVES OF OVERALL TEST PROGRAM

Testing of the AN/TCC-35 was conducted on equipment installed in operational FPIS Radio Circuits, and at RADC Laboratories. The general objective of the tests was to determine the suitability of the Rixon Sixteen-Channel Multiplex Equipment (AN/TCC-35(XD-1)) to meet the operational requirement for a multiplex equipment to be used with ionospheric scatter radio circuits for the purpose of increasing the information handling capability.

Operational tests were conducted by the Air Force Operational Test Center (AFOTC) over the Wachusetts - Goose Bay FPIS circuit, beginning 21 October 1957, for a duration of 180 days terminating on 31 March 1958. These tests were conducted using six AN/TCC-35 multiplex equipments (serial numbers 1 through 6) as follows:

- (a) One at Wachusetts, Massachusetts,
- (b) Two at Goose Bay, Labrador,
- (c) Two at BW-8, Greenland, and
- (d) One at Thule, Greenland.

The basic test objective during the main phase of the operational program was to ascertain the performance and reliability of the equipment and all components by determining the accuracy of transmission and reception of information.

Evaluation tests were performed by RADC personnel at RADC Laboratories. The re-circulation or loop test was used to accomplish the major objective of the test, namely, to determine the reliability of the equipment during back-to-back operation, for an extended period of time, at standard laboratory conditions. Bounce tests and shipping tests were also conducted, to determine the ruggedness of the equipment. Finally, high temperature, low temperature and barometric pressure tests were performed to determine the operating capability of the equipment under varying environmental conditions.

RADC EVALUATION TESTING

BACKGROUND

Evaluation tests were conducted between November, 1957 and July, 1958 in the equipment laboratory of RADC on two units of the AN/TCC-35 equipment, serial numbers 7 and 8. During this time, the equipments were subjected to endurance, ruggedness and environmental testing.

ENDURANCE TESTS

The purpose of the endurance tests was to determine the operability of the AN/TCC-35 over an extended period of time. The equipment was tested using the re-circulating or loop test in back-to-back operation. The Automatic Fox Generator (The quick brown fox jumped over the lazy dog's back 0123456789) TS-2B/TG Test Set was used to insert data into Channel 1 of the transmitting multiplexer. The output of Channel 1 was inserted into the input of Channel 1 receiving multiplexer. The output of Channel 1 receiving multiplexer was inserted into

Channel 2 of the transmitting multiplexer. The output of Channel 2 transmitting multiplexer was inserted into Channel 2 of the receiving multiplexer. Finally, the output of Channel 16 receiving multiplexer was substituted for the TS-2B/TG and inserted into Channel 1 of the transmitting multiplexer. Because of the delay encountered in this looping operation, 38 of the characters in the test message became trapped in the equipment. An AN/FGC-20 TTY Page Printer was used to monitor the output of one of the receiving multiplex channels and to facilitate error counts. The page printer was automatically timed to operate approximately one minute out of each 20 minutes of system operation. The tests were conducted with the equipment operating at 60 words per minute and 100 words per minute. Error-free periods exceeding 120 hours at each speed were recorded. Line voltage was recorded on a pen recorder and errors could usually be correlated to sharp line voltage fluctuations.

RUGGEDNESS TESTS

Ruggedness tests consisting of shipping and bounce tests were conducted in an attempt to simulate the most extreme mechanical stresses to which the equipment would be subjected. The equipment satisfactorily passed the shipping tests. The bounce test was conducted in accordance with MIL-T-4734 on a package testing machine with a capacity of 1000 pounds and a table measuring 5 feet by 5 feet, IAB Corporation Type 1000E. The transit case with its enclosed equipment was placed unpackaged on the floor of the package testing machine. The machine was set to run at 285 rpm, for both synchronous and

asynchronous drive. The rectangular transit case was subjected to the bounce test for a total of 3 hours: 15 minutes on each face for a total of 1-1/2 hours with synchronous drive, and 15 minutes on each face for 1-1/2 hours asynchronous drive. Cylindrical cases were placed on the tester so that the cylindrical surface was against the floor and the tester was run at synchronous drive for 1-1/2 hours, and at asynchronous drive for 1-1/2 hours. Upon completion of the tests there was no evidence of damage to the case, such as openings along joints, loosening of partitions, splitting of corners and opening of catches.

ENVIRONMENTAL TESTS

The AN/TCC-35 was subjected to anticipated environmental extremes by the use of high temperature, low temperature and barometric pressure tests. The environmental tests were conducted in accordance with Exhibit AFCRC 56-20A and other specifications referenced therein. During the high temperature test, conducted in accordance with paragraph 4.3.2.1 of the Exhibit, the equipment failed to operate satisfactorily. Transistors in the equipment were the prime cause of failures; bad pin connections, both on the module packages and between the modules, also contributed to the failures. The low temperature test was conducted in accordance with AFCRC 56-20A, paragraph 4.3.2.2; the equipment operated satisfactorily when subjected to it. The procedure outlined in paragraph 4.3.2.3 of the above specification was used to conduct the barometric pressure test, which the equipment satisfactorily passed.

EVALUATION TEST RESULTS AND CONCLUSIONS

In summary, the endurance phase of the evaluation tests indicated that the AN/TCC-35 is capable of reliable performance for extended periods of time, when operating back-to-back with other AN/TCC-35 equipments. The results of the ruggedness and environmental tests are briefly summarized as follows:

<u>TEST</u>	<u>RESULT</u>
Shipping	Passed
Bounce	Passed
High Temperature	
a. 54°C Operating	Marginal
b. 71°C Non-operating	Marginal
Low Temperature	
a. -18°C Operating	Passed
b. -54°C Non-operating	Passed
Barometric Pressure	Passed

It was concluded that the AN/TCC-35 design is basically sound. By modifying certain transistorized circuits to incorporate greater overload capacity, and by improving heat transfer characteristics of heat-sensitive components, the equipment probably can be redesigned to pass satisfactorily the high temperature test.

AFOTC OPERATIONAL TESTING

TEST OBJECTIVES AND REQUIREMENTS

Operational tests were conducted by AFOTC on six AN/TCC-35 units, serial numbers 1 through 6. Airways and Air Communication Service (AACS) installed, maintained, and operated the six multiplex equipments.

Eight factors were considered:

- (1) Rate and accuracy at which information could be transmitted and received,
- (2) Reliability of the equipment,
- (3) Comparison of the equipment with high frequency (hf) predicted wave teletype multiplex in terms of channel capacity, communications reliability and equipment reliability,
- (4) Capability of the equipment to function despite Electronic Counter-Measures (ECM),
- (5) Training requirements for operating and maintenance personnel,
- (6) Maintainability of the equipment (including completeness of maintenance manuals),
- (7) Adequacy of test equipment, and
- (8) Compatibility of the AN/TCC-35 with existing USAF radio and TTY equipment, particularly as an integrated part of the STRATCOM system.

Information of the above type would be extremely useful in planning further installations of the equipment. Careful evaluation of the

difficulties encountered would permit determination of the levels of specialized formal training required for personnel maintaining the AN/TCC-35. Analysis of component failures during the testing program would be instrumental in determining the type and quality of spare parts to be stocked.

Testing of the AN/TCC-35 was conducted on FPIS radio circuits using pre-cut tape over any channel available and operational traffic on any channel over which such traffic was flowing. Testing hours for the four days per week allocated by AACS for testing on the FPIS circuits were left to the discretion of the site test Project Officer. A minimum of eight hours per day of testing was considered necessary to assure reasonable statistical validity of test data. A "Weekly Summary of Tests" was submitted on the total number of characters transmitted and received and on the total number of garbled or missed characters. All failures of equipment were also documented by test personnel, on "Failure Reports" submitted periodically.

DESCRIPTION OF TESTS AND TEST EQUIPMENT

Tests were conducted on the AN/TCC-35 equipment at 60 and 100 word-per-minute speeds in order to determine output distortion and operational stability. Troubleshooting and regular maintenance techniques were observed in an effort to determine accessibility of components and sub-units and ease of maintenance. Test equipment used in these tests included: DuMont Oscilloscope (Type 304-H), Automatic Telephone and Electric Co., Ltd., Transmission Distortion Measuring

Set (TDMS) 4B (Sender) and TDMS 6A (Receiver); Model 19 (TT-7/FG) Teletypewriter Unit. The test equipment provided with the AN/TCC-35, and other miscellaneous test equipment (e.g., ohmmeters), completed the equipment used.

The tests to be described below were not performed on operational circuitry, but were confined to the circuitry available at the test site. Prior to the tests accomplished and described in this report, site personnel had been operating the AN/TCC-35 at 45.5 Baud input modulation rates, terminating one channel in a relay and operating the transmitter and receiver units back-to-back: that is, Transmit Channel 1 feeding Receive Channel 1, Receive Channel 1 output feeding Transmit Channel 2, etc. The input to Transmit Channel 1 was from a local Transmitter-Distributor (TD), transmitting the standard FOX test. Rixon CV-440 Voltage-to-Current Converters were used in the output loop of each transmit channel.

The first operational test consisted of transmitting information from the TDMS 4B Teletype Signal Generator at 45.5 Baud. This unit is capable of sending either message information or single character information. The test setup of the AN/TCC-35 remained as described above. However, rather than the relay termination, a resistive load was used to terminate the circuit. The oscilloscope and the TDMS 6A were connected across this load. In addition, the axis output of the TDMS 6A was connected to the axis connection of the oscilloscope in order to view the axis bright-ups on the oscilloscope. Both input to

and output from the circuit were monitored on a Model 19 Teletypewriter Unit. With regular message information the complete circuit operated satisfactorily. With zero distortion at the input, the output distortion was approximately 1% spacing bias. The message information was switched off and a steady character (Y) was fed to the input of the circuit. Occasionally the various channels would become inoperative with the steady character. It was determined that the cause of this trouble existed in the Voltage-to-Current Converters, several of which did not provide sufficient current for the output loop. This trouble was attributed to insufficient range of the "Current Adjust" control on the unit due to aging of the transistors and diodes within the unit. When the situation was corrected it was possible to transmit steady characters through the circuit with approximately 1% spacing bias distortion at the output when the input distortion was zero.

The configuration described above was utilized in making tests at 74.2 Baud. The necessary strapping and crystal changing was performed on the AN/TCC-35 equipment to permit 74.2 Baud input modulation rate operation. The TDMS 4B and TDMS 6A were set for the same speed. No printer was available at the test site with which to monitor the transmissions at this speed. With proper adjustment of the Voltage-to-Current Converter "Current Adjust" controls, no difficulty was experienced when transmitting message or steady character information. With zero input distortion the output distortion was approximately 1% spacing bias, regardless of whether message or steady character was fed into the circuit.

It was desired to distort the waveshape of the incoming signal in order to determine how much waveshape distortion could be introduced and still obtain satisfactory output; however, this test was not practicable at the test site due to lack of necessary equipment.

During the testing period the input signal current tolerance was examined, and it was found that the Transmitter Code Converter would not accept much more than a 10% drop in line current when the input circuit was optioned for neutral 60 ma signals.

MAINTAINABILITY. During the operational testing some maintenance was performed by site technicians. It was observed that access to many components within the various units was difficult. Troubleshooting of various major units was accomplished with the units swung out on the hinges which hold the units in place on the rack. Swinging the units out into the aisle resulted in partially blocking the aisle. This occurred both in front and behind the AN/TCC-35 racks, since major units are placed on both sides.

In many cases maintenance and repair of the equipment required a great deal of time. Inadequate training of the maintenance personnel seemed to account for this; the Weekly Operating and Failure Reports substantiated this judgment. The following remarks attached to one of the failure reports submitted by AACS personnel summarizes the maintenance problem that existed during testing of the MUX units:

"It should be noted that there are not sufficient personnel familiar with the above equipment at this station to provide the proper kind of attention to the equipment. All except one of the men trained on MUX-16 have rotated. It would be extremely desirable to have personnel available to provide 24 hour per day maintenance. Probably, the outage time could be reduced by a considerable percentage."

The package or module test unit, which is installed in the receiver rack, was used to perform maintenance on various defective and operative sub-unit modules. The unit appeared to perform satisfactorily in conjunction with the built-in test oscilloscope. Wave forms indicated in the maintenance section of the instruction book were obtained. However, the test unit does not completely test a package, since the instructions call for an ohmmeter check of some packages.

OPERATIONAL TEST RESULTS AND CONCLUSIONS

RESULTS. During the AFOTC operational tests, test personnel reported the following mechanical and physical aspects of the unit:

(1) Considerable space is wasted. Plug-in modules have been used but the space-saving advantage they impart has not been fully utilized in the physical layout and construction of the unit.

(2) The test oscilloscope in the receive unit does not have satisfactory ventilation. Inadequate clearance causes the oscilloscope

to overheat in normal operation, ultimately resulting in a high tube failure rate.

(3) A majority of components are mounted on both upper and lower sides of horizontal terminal boards, precluding replacement of defective components while the major unit is in its rack. In lower units maintenance can be performed only by changing plug-in modules.

(4) During maintenance of the equipment, aisle space was seriously reduced. Due to the method of hinging major units to the rack, the units extend a considerable distance into the aisle when perpendicular to the rack. Since major units are mounted in both the front and rear of the racks, the problem could be acute in certain installations.

(5) Maintenance of the major units mounted on the rear of the racks was difficult to perform with the two test oscilloscopes mounted on the receive and transmit racks. Since the oscilloscope input cable must be connected to the unit under test from the rear of the rack, the oscilloscope pattern should be visible from that position. However, in the AN/TCC-35 the maintenance technician, after connecting the oscilloscope input cable to the test point, must observe the oscilloscope pattern from the front of the unit. Considerable time is thus wasted.

(6) A sub-panel on the package test unit, when in position, touched several components mounted on terminal strip TB-1. Components on this terminal board should be rearranged.

(7) Damage during shipment suggests that packaging techniques should be improved.

The following observations of an electronic nature were recorded:

(1) Range of the "Current Adjust" control is unstable. In most units, aging of diodes and transistors necessitated maximum adjustment of this control to obtain adequate line current. By correcting this fault, operation of the Voltage-to-Current Converter could be improved.

(2) Voltage-to-Current Converters required unorthodox battery connections for correct operation.

(3) Because the Converter effective source impedance is too high (700 ohms), the open circuit output rises to 225 volts, which is too high.

(4) As a result of using encapsulated modules to package transistor and magnetic core devices, there are too many mechanical connections. For example, an Input Code Converter uses approximately 20 packages within its circuitry and has, accordingly, more than 200 mechanical connections.

(5) The AN/TCC-35 did not operate well with some standard types of TTY equipment, though its operation with other AN/TCC-35 units was satisfactory. When receiving signals from a remote Plan 51-TD equipment there were some garbled and missed characters, presumably because of uncorrected waveshape distortion of the signal being processed. Further, the 20-volt signals of the AN/TCC-35 receive channel outputs are not compatible with standard AACS TTY printers.

In general, the electrical design of the equipment is considered good. The equipment can be used with the modifications discussed in

this report for increasing channel capacity on FPIS or STRATCOM circuits; however, it may not be suitable for use in the overall STRATCOM system.

CONCLUSIONS. Based on the results of the AFOTC operational tests it was possible to draw a number of conclusions:

(1) The mechanical engineering of the AN/TCC-35 must be improved with regard to packaging of units. There is insufficient ventilation area for the test oscilloscope, and its location does not permit easy use of it for maintenance.

(2) The type of relay in the Voltage-to-Current Converter is not adequate.

(3) The receive channel output load now in the AN/TCC-35 is not as reliable as a good polar signal relay would be.

(4) Tolerance of the input circuits of the Transmitter Code Converter is too narrow; it will not function with a 10% or more drop in line current.

(5) Investigation of encapsulating techniques for diodes, magnetic cores, and transistors was not sufficient, and these devices do not function well in the equipment.

(6) In its present form, the AN/TCC-35 is unsuitable for integration with existing USAF radio and TTY communications equipment and with USAF security equipment used in the STRATCOM system.

RECOMMENDATIONS

Circuitry modifications to improve compatibility and reliability are recommended as a result of field experience on the FPIS radio circuits, evaluation at RADC, and an engineering study of certain additional operating features. These suggested improvements fall into three general categories:

(1) Certain internal timing sequences should be revised to increase tolerance to fortuitous distortion of TTY input signals and, if required, to provide transmission capability for 8.0 unit code on selected channels.

(2) Circuit changes must be made to improve tolerance to environmental conditions and to reduce the critical performance standards required of certain components or replaceable units.

(3) Circuit changes must be made to improve compatibility of the equipment with AACS technical control facilities and installed equipment.

Item 1 and a portion of item 3 have been the subject of a study contract. Item 2 and the remaining portion of item 3 are the result of investigation of reported performance difficulties with, or deficiencies in, the equipment at RADC, the FPIS installations, and new equipment manufactured from the original design data. The reasons for the deficiencies are now well understood, and the resulting circuit changes are very effective in eliminating or greatly reducing the problems.

Careful evaluation of this work permits the following recommendations:

(1) Modify all units to improve tolerance to fortuitous distortion of TTY input signals.

(2) Investigate the operational requirement for 8.0 unit code transmission on the North Atlantic FPIS system. If this is an operational requirement, two or more channels should be modified accordingly.

(3) Continue to use presently installed Voltage-to-Current Converters, since it is understood that a conversion to polar operation is planned for the immediate future. The plus or minus 20-volt output from the AN/TCC-35 receiver circuits is ideally suited for the direct operation of polar relays that will be required. Although solid state equivalents of dry contact output circuits are technically feasible and highly reliable their cost is still very high.

(4) The following circuit changes should be made to improve performance and reduce sensitivity to plug-in component variations.

- (a) Re-design the start pulse detector on each of the 16 TTY input channels to reduce false start susceptibility.
- (b) Change the output circuit in each of the 16 receiving code converters to increase tolerance to wide variations in output flip-flop unit and virtually to eliminate the high replacement rate for this unit.
- (c) Change the operating bias levels on all flip-flop units to insure reliable operation without selective elimination of marginal units.

- (d) Insert current limiting resistors in certain transistor circuits to eliminate early failure or inadvertent burn-out due to malfunction of circuits.

SUMMARY

Experimental models of the AN/TCC-35 that were procured in the service test category are considered unsuitable for USAF operational service. Tests described in this report substantiate such a conclusion. If systems of this capability are required for USAF use, it is recommended in the interest of standardization that the AN/FGC-54 be procured. This course of action would be economical for the following reasons: (1) Time and money savings in connection with the modifications necessary to produce a suitable AN/TCC-35; (2) considerations of logistic support, training and maintenance.

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